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A pioneering exploration of soil mite biodiversity in Isfahan, in the center of Iran

(Acari, Prostigmata and Mesostigmata)

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The current study was carried out during 2018–2019, to evaluate the biodiversity of soil mites in Isfahan parks. Totally, 50 species of Prostigmata and Mesostigmata were collected and identified, representing 36 genera and 26 families. The species diversity in 5 sites, including the north, south, west, east, and center of the Isfahan metropolis, was also calculated. The highest values for both Shannon-Wiener (3.001) and Simpson (0.925) indices were assigned to site 4 (southern site). *Arctoseius cetratus* was recorded as the dominant species, whereas *Alliphis halleri*, *Veigaia planicola*, *Blattisocius tarsalis*, *Rhagidia* sp., *Tarsanemus* sp., *Tydeus* sp., and *Macrocheles* sp. had the lowest abundance.

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Introduction

Soil is one of the most important and diverse ecological habitats (Mohammad-Dustar-Sharaf et al. 2016). Soil organisms play important roles in the environmental system and could be considered the indicators to assess soil quality and to inform about the soil status in agricultural and forestry environments (Schloter et al. 2003). Arthropods are important components of soil fauna. Among them, mites are one of the best representatives of arthropods in the soil due to their species diversity, ecological niche and behaviour (Bedano et al. 2005, Speight et al. 2008). Walter & Proctor (2013) introduced a system that recognizes the three orders Opilioacariformes, Parasitiformes, and Acariformes within Acari (Krantz & Walter 2009). Prostigmata currently includes 140 families, more than 1100 genera and about 21 400 species in the world. Soil Prostigmata form an important part of this number, which includes 60 families, 681 genera, and approximately 6400 species. According to Kamali et al. (2001) 70 families, 222 genera and 446 species have been reported from the Prostigmata fauna of Iran. The number of recorded Mesostigmata species are more than 12 000 species in the world, but only 348 species have been reported from Iran (Abbaspour et al. 2016). The most important long-term goal for maintaining ecosystem function is the protection of biodiversity (Mohammad-Dustar-Sharaf et al. 2016). The greater the biodiversity in an ecosystem, the healthier and more sustainable the environment and the more self-regulating the conditions (Zhang 2003). Therefore, biodiversity in any site is the key to the health and sustainability of the environment

Figs 1–2. Sampling sites in the Isfahan province, Iran. **1.** Site 1 (East). **2.** Site 2 (West).

(Hajizadeh et al. 2010, Heidari Latibari et al. 2022). The soil type, soil moisture, pH and geographical location cause differences in the population density of mites in the soil (Manu 2013). Forest management strategies and human activities can play an important role in reducing the quantity and diversity of Mesostigmata (Salmane 2003, Sabbatini Peverieri et al. 2011). The diversity of soil mites in habitats with more vegetation and no chemicals is higher compared to habitats with less vegetation and chemical pesticides and fertilizers (Perez-Velazquez et al. 2011). Determining the diversity of mites in green space determines the stability and dynamics of the ecosystem, soil quality, and evaluation of management (Maleki et al. 2016). So far, little research has been done in this field in Iran and the world (Kazemi 2011, Kazemi & Rajaei 2013, Maleki et al. 2016). Considering 3700 hectares of urban green space in Isfahan, this study was conducted to determine the diversity of soil mites in Isfahan green space for the first time.

Material and methods

The present study aimed to understand the diversity of soil-dwelling Prostigmata and Mesostigmata in Isfahan parks from 2018 to 2019. Sampling was conducted at 24

Table 1. Geographical and vegetation characteristics and humidity percent (%) of sampling sites in parks of Isfahan in 2019.

Region	Latitude and longitude of sampling site	Vegetation characteristics	Humidity (%)
1 East	32°38'32" N, 51°42'50" E	Conifers and shrubs as cover plant	51.15
2 West	32°38'17" N, 51°38'16" E	Broad-leaved trees as cover plant	53.44
3 North	32°40'53" N, 51°38'22" E	Conifers and shrubs as cover plant	38.55
4 South	32°35'42" N, 51°39'11" E	Broad-leaved trees as cover plant	48.19
5 Center	32°38'19" N, 51°38'50" E	Conifers and shrubs as cover plant	42.19

Figs 3–4. Sampling sites in the Isfahan province, Iran. **3.** Site 3 (North). **4.** Site 4 (South).

stations in five sampling sites (Figs 1–5), each representing different ecological and geographical features (Table 1) across the four seasons. To facilitate statistical analysis, these stations were selected based on their geographical location in five directions: north, south, east, west, and center. Air humidity was measured at each site using a hygrometer during sampling. The lowest moisture content was observed in summer, while the highest was in winter. Soil samples were collected every 15 days from a depth of 10–15 cm using a shovel, with four points sampled in a zigzag pattern at each site. These samples were placed in dark plastic bags labelled with sampling date and geographical details. The bags were then transported to the laboratory, where

Fig. 5. Sampling site 5 (Center) in the Isfahan province, Iran.

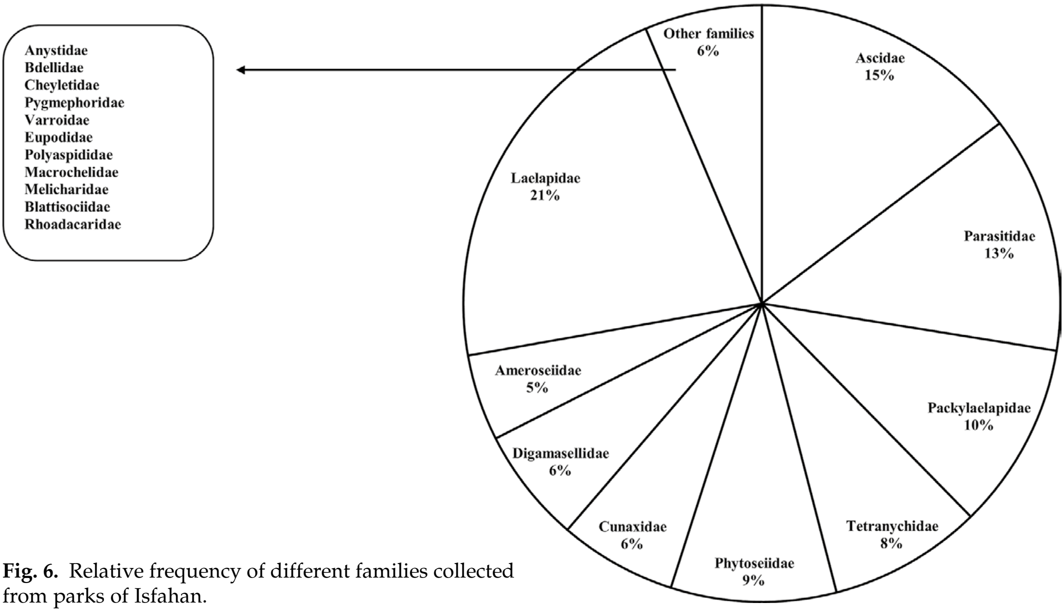

Fig. 6. Relative frequency of different families collected from parks of Isfahan.

the samples from each station were combined into a single mixture. A portion of this mixture was placed in a Berlese funnel for 48 to 72 hours to collect the mites.

The collected samples were separated and identified using taxonomic keys, and a number of samples were sent to an expert for confirmation. The frequency of mites by family, sex, species, and number of males and females was recorded, along with their distribution across seasons and their relationship with soil and environmental conditions. The diversity coefficient was calculated for each site and for the total sampled sites. Species diversity indices were calculated using Excel 2010 and SDR v.4.

Results

Abundance

A total of 50 species from the Mesostigmata order and Prostigmata suborder were collected and identified at selected sites, across 36 genera and 26 families. Among these, 38 species belonged to the Mesostigmata order, and the remaining 12 were attributed to the Prostigmata suborder. Over the course of a year, a collection of 770 samples revealed that 165 individuals from Laelapidae family from the Stigmata order, constituted 21.42 % of the total mites collected, holding the largest share compared to other families. Following the Laelapidae family, the Ascidae family, with 113 specimens and a share of 14.67 %, secured the second position (Fig. 6).

Arctoseius cetratus, a member of the Ascidae family, exhibited the highest abundance among the species gathered, with a total of 101 samples (Table 2). Notably, this species features a broad and circular middle pad on its second to fourth legs, and its palp paw lacks macrostas. Within the suborder Prostigmata, *Tetranychus* sp., stood out as the most abundant group, with a total of 64 specimens recorded (Table 2). The species *Arctoseius cetratus* emerged as the most dominant, boasting a dominance value of 13.11 %. On the other hand, species as *Alliphis halleri*, *Veigaia planicola*, *Blattisocius tarsalis*, *Rhagidia* sp., *Tarsanemus* sp., *Tydaeus* sp., and *Macrocheles* sp. exhibited the lowest dominance rates, collectively amounting to 0.129 % (Fig. 7). Among the gathered samples, 98 individuals were in the immature stages, while 260 were male, and 412 were female.

Biodiversity indices

During the summer season, a total of 267 samples were collected. The samples obtained in the first 6 months of the year totalled 514, while those in the second 6 months amounted to 256.

The Shannon-Wiener index, ranging between 2–3 in sites one to five, indicates average biodiversity in the sampled sites. Site four exhibited the highest Shannon-Wiener index value 3.001 (Table 3).

Species richness, evaluated using the Margalef and Menhinck indices, revealed that the fourth site had the highest Margalef richness, and the third

Table 2. Number of mites for each sampling region in parks of Isfahan in 2019.

No	Family	Species	Total amount	Site 1	Site 2	Site 3	Site 4	Site 5
1	Ascidae	*Arctoseius cetratus*	101	17	19	5	31	29
2	Parasitidae	*Parasitus* sp.	90	12	16	16	16	30
3	Packylaelapidae	*Onchodellus karawaiewi*	78	13	28	0	23	14
4	Tetranychidae	*Tetranychus* sp.	64	13	11	17	11	12
5	Phytoseiidae	*Neoseiulus barkeri*	56	8	16	14	16	2
6	Cunaxidae	*Cunaxa setirostris*	49	7	21	11	10	0
7	Digamasellidae	*Dendrolaelaps* sp.	48	16	4	22	4	2
8	Ameroseiidae	*Ameroseius lidiae*	34	4	10	10	2	8
9	Laelapidae	*Euandrolaelaps karawaiewi*	32	3	3	4	18	4
10	Laelapidae	*Haemolaelaps shealsi*	26	7	0	3	16	0
11	Laelapidae	*Gaeolaelaps queenslandica*	24	0	3	2	15	4
12	Laelapidae	*Cosmolaelaps lutegiensis*	22	5	5	7	0	5
13	Laelapidae	*Pogonolaelaps canestrinii*	16	0	7	7	2	0
14	Anystidae	*Anystis baccarum*	11	6	0	5	0	0
15	Phytoseiidae	*Proprioseiopsis messor*	11	0	5	1	0	5
16	Parasitidae	*Parasitus mycophilus*	9	0	5	0	3	1
17	Laelapidae	*Pneumolaelaps sclerotarsus*	7	0	1	2	4	0
18	Laelapidae	*Gymnolaelaps obscuroides*	7	0	6	1	0	0
19	Laelapidae	*Hypoaspisella asperatus*	7	0	0	2	3	2
20	Laelapidae	*Gaeolaelaps* sp.	6	2	1	1	0	2
21	Laelapidae	*Gaeolaelaps aculeifer*	5	3	0	0	2	0
22	Bdellidae	*Spinibdella cronini*	5	0	0	1	4	0
23	Cheyletidae	*Cheyletus aversor*	4	0	0	0	2	2
24	Ascidae	*Asca aphidioides*	4	2	2	0	0	0
25	Laelapidae	*Cosmolaelaps claviger*	4	0	0	0	2	2
26	Pygmephoridae	not identified	4	0	2	0	2	0
27	Varroidae	*Varroa destructor*	3	0	2	0	1	0
28	Laelapidae	*Hypoaspis quadridentatus*	3	0	3	0	0	0
29	Ascidae	*Antenoseius bacatus*	3	0	0	0	3	0
30	Ascidae	*Arctoseius pristinus*	3	0	3	0	0	0
31	Eupodidae	*Eupodes* sp.	3	0	0	3	0	0
32	Ascidae	*Protogamasellus massula*	2	0	0	2	0	0
33	Polyaspididae	*Polyaspis berlesei*	2	0	0	0	2	0
34	Phytoseiidae	*Neoseiulus bicadus*	2	0	0	2	0	0
35	Macrochelidae	*Macrocheles insignitus*	2	0	0	2	0	0
36	Ameroseiidae	*Ameroseius plumosus*	2	0	0	0	0	2
37	Melicharidae	*Proctolaelaps pygmaeus*	2	0	0	0	2	0
38	Blattisociidae	*Lasioseius* sp.	2	0	0	0	1	1
39	Rhoadacaridae	*Rhoadacarellus* sp.	2	0	0	2	0	0
40	Laelapidae	*Hypoaspisella patagoniensis*	2	1	0	0	0	1
41	Halolaelapidae	*Halolaelaps* sp.	2	0	0	0	2	0
42	Laelapidae	*Gaeolaelaps neoaculeifer*	2	0	0	0	2	0
43	Laelapidae	*Gaeolaelaps* sp.	2	0	2	0	0	0
44	Eviphididae	*Alliphis halleri*	1	1	0	0	0	0
45	Veigaiidae	*Veigaia planicola*	1	0	1	0	0	0
46	Blattisociidae	*Blattisocius tarsalis*	1	1	0	0	0	0
47	Rhagidiidae	*Rhagidia* sp.	1	1	0	0	0	0
48	Tarsonemidae	*Tarsonemus* sp.	1	0	0	0	0	1
49	Tydaeidae	*Tydeus* sp.	1	1	0	0	0	0
50	Macrochelidae	*Macrocheles* sp.	1	1	0	0	0	0
		Total	770	124	176	142	199	129

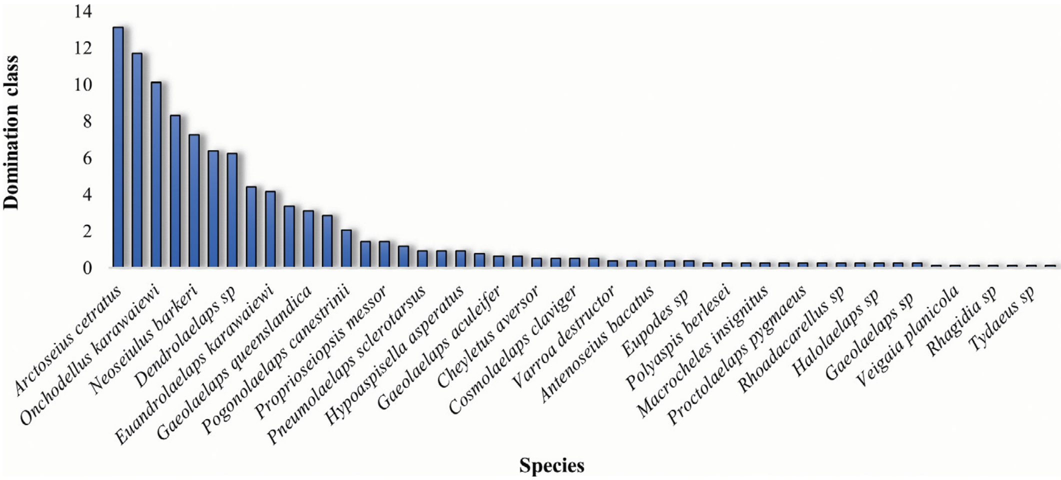

Fig. 7. Dominancy in species abundance of soil mites collected in parks of Isfahan.

(north) site had the highest Menhinck richness, while the fifth site had the lowest richness (Table 3).

Uniformity in these sites was measured using the Hill and Peet indices. Site 4 showed the highest Peet index, and site 1 (east) had the lowest. The Hill index displayed the highest value for site 1 and the lowest for site 4 (Table 3).

Discussion

The number of collected samples in the first 6 months of the year was 514 samples, while in the second 6 months, it was 256 samples, indicating a significant difference in mites' population between spring/summer and winter/autumn (Table 4). This variation could be influenced by atmospheric and soil moisture conditions, as Salmane (2000) noted that biodiversity changes in response to temperature and humidity. Examining soil mites' fauna and their diversity in relation to plant types revealed that sites with broad-leaved trees and dense tree cover had a richer fauna of soil mites compared to sites dominated by coniferous trees and shrubs. The presence of decorative trees contributed to greater shading and moisture retention in the soil, explaining the increased variety of soil mites. Conversely, sites with direct sunlight exposure, weaker vegetation like grassy sites, and lower ornamental shrubs showed lower species diversity of soil mites, possibly due to faster soil moisture evaporation under sunlight. Kiasari et al. (2011) supported these findings, demonstrating the impact of vegetation cover, environmental conditions, and soil type on the diversity and density of soil invertebrate populations. The research highlighted that the summer season yielded the largest number of collected samples, emphasizing the influence of temperature on mite abundance. Gergocs & Hufnagel (2009) suggested that temperature directly affects mite behaviour and indirectly influences population size through its impact on food availability.

The Shannon-Wiener index in Mirfakhrai et al.'s (2016) study at Urmia University campus ranged from 0 to 1.78, showing higher diversity in our

Table 3. Indices of biodiversity, species richness and evenness in parks of Isfahan.

Biodiversity parameters	Site 1	Site 2	Site 3	Site 4	Site 5	Total
Total Number of individuals in the site	124	176	142	199	129	770
Total Number of species in the site	21	24	24	27	20	50
Simpson index	0.923	0.922	0.924	0.925	0.871	0.931
Shannon-Wiener index	2.159	2.656	2.536	3.001	2.408	1.319
Margalef richness index	4.149	4.448	4.641	4.911	3.90	7.372
Menhinick richness index	1.885	1.809	2.014	1.913	1.760	1.801
Peet index	0.709	0.833	0.796	0.915	0.801	0.337
Hill index	0.501	0.408	0.427	0.360	0.478	0.814

Table 4. Number of specimens in different seasons in parks of Isfahan.

No	Family	Species	Total amount	Spring	Summer	Autumn	Winter
1	Ascidae	*Arctoseius cetratus*	101	53	21	17	10
2	Parasitidae	*Parasitus* sp.	90	50	23	11	6
3	Packylaelapidae	*Onchodellus karawaiewi*	78	5	44	18	11
4	Tetranychidae	*Tetranychus* sp.	64	41	9	3	11
5	Phytoseiidae	*Neoseiulus barkeri*	56	25	6	25	0
6	Cunaxidae	*Cunaxa setirostris*	49	3	37	9	0
7	Digamasellidae	*Dendrolaelaps* sp.	48	7	8	26	7
8	Ameroseiidae	*Ameroseius lidiae*	34	8	19	4	3
9	Laelapidae	*Euandrolaelaps karawaiewi*	32	0	19	7	6
10	Laelapidae	*Haemolaelaps shealsi*	26	6	12	6	2
11	Laelapidae	*Gaeolaelaps queenslandica*	24	7	7	10	0
12	Laelapidae	*Cosmolaelaps lutegiensis*	22	5	5	6	6
13	Laelapidae	*Pogonolaelaps canestrinii*	16	5	11	0	0
14	Anystidae	*Anystis baccarum*	11	0	3	8	0
15	Phytoseiidae	*Proprioseiopsis messor*	11	0	5	6	0
16	Parasitidae	*Parasitus mycophilus*	9	2	5	2	0
17	Laelapidae	*Pneumolaelaps sclerotarsus*	7	4	2	1	0
18	Laelapidae	*Gymnolaelaps obscuroides*	7	0	3	4	0
19	Laelapidae	*Hypoaspisella asperatus*	7	5	2	0	0
20	Laelapidae	*Gaeolaelaps* sp.	6	1	2	3	0
21	Laelapidae	*Gaeolaelaps aculeifer*	5	0	3	1	1
22	Bdellidae	*Spinibdella cronini*	5	0	3	2	0
23	Cheyletidae	*Cheyletus aversor*	4	0	0	2	2
24	Ascidae	*Asca aphidioides*	4	2	0	2	0
25	Laelapidae	*Cosmolaelaps claviger*	4	0	0	3	1
26	Pygmephoridae	not identified	4	0	2	0	2
27	Varroidae	*Varroa destructor*	3	0	0	3	0
28	Laelapidae	*Hypoaspis quadridentatus*	3	2	0	1	0
29	Ascidae	*Antenoseius bacatus*	3	3	0	0	0
30	Ascidae	*Arctoseius pristinus*	3	0	2	0	1
31	Eupodidae	*Eupodes* sp.	3	0	2	1	0
32	Ascidae	*Protogamasellus massula*	2	1	0	0	1
33	Polyaspididae	*Polyaspis berlesei*	2	0	2	0	0
34	Phytoseiidae	*Neoseiulus bicadus*	2	2	0	0	0
35	Macrochelidae	*Macrocheles insignitus*	2	2	0	0	0
36	Ameroseiidae	*Ameroseius plumosus*	2	0	2	0	0
37	Melicharidae	*Proctolaelaps pygmaeus*	2	0	2	0	0
38	Blattisociidae	*Lasioseius* sp.	2	0	1	1	0
39	Rhoadacaridae	*Rhoadacarellus* sp.	2	0	2	0	0
40	Laelapidae	*Hypoaspisella patagoniensis*	2	0	1	0	1
41	Halolaelapidae	*Halolaelaps* sp.	2	2	0	0	0
42	Laelapidae	*Gaeolaelaps neoaculeifer*	2	1	0	1	0
43	Laelapidae	*Gaeolaelaps* sp.	2	2	0	0	0
44	Eviphididae	*Alliphis halleri*	1	1	0	0	0
45	Veigaiidae	*Veigaia planicola*	1	0	1	0	0
46	Blattisociidae	*Blattisocius tarsalis*	1	1	0	0	0
47	Rhagidiidae	*Rhagidia* sp.	1	1	0	0	0
48	Tarsonemidae	*Tarsonemus* sp.	1	0	0	1	0
49	Tydaeidae	*Tydeus* sp.	1	0	0	1	0
50	Macrochelidae	*Macrocheles* sp.	1	0	1	0	0
		Total	770	247	267	185	71

study. Comparing with Maleki et al.'s (2016) research in Tehran Police Park, our Shannon-Wiener index aligns. By examining Simpson's index, high value sites exhibit good diversity. The fifth site (center) has the lowest Simpson's index due to central parks' pollution and human activities, resulting in lower diversity with 20 mite species, the fewest among sites. The fifth site (center) has the lowest Simpson's index due to central parks' pollution and human activities, resulting in lower diversity with 20 mite species, the fewest among sites. Site 4 (south) has the highest species diversity, justified by the southern parks' forested nature like Sefe Forest Park. With 27 out of 50 species collected in a year, it has the highest share. Central sites exhibit the lowest diversity and species richness. The high Peet index in site 4 indicates less rare species and more dominant ones. High indices like Shannon-Wiener indicate stability. Site 4 has the highest biodiversity. The study aligns with Perez-Velazquez et al. (2011), indicating higher biodiversity in sites with more vegetation and fewer chemicals. Site 4, with Mount Safa and less human activity, has higher biodiversity and less soil pollution. While site 1, with the lowest Shannon-Wiener index, has the highest Hill index, showing an inverse relationship. Factors like vegetation, management methods, and environmental changes affect mite abundance and biodiversity.

Conclusion

Soil organisms such as mites emerge as valuable biological indicators for estimating soil pollution levels. Their higher species diversity serves as a reliable indicator, suggesting a lower percentage of soil pollution. This underscores the importance of considering the biodiversity of soil-dwelling organisms, particularly mites, in environmental assessments. Harnessing the potential of these organisms as biological indicators can provide valuable insights into the overall health and ecological balance of soil ecosystems. As we strive for sustainable environmental management, monitoring soil mite diversity can play a pivotal role in gauging the impact of human activities on soil health and pollution.

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